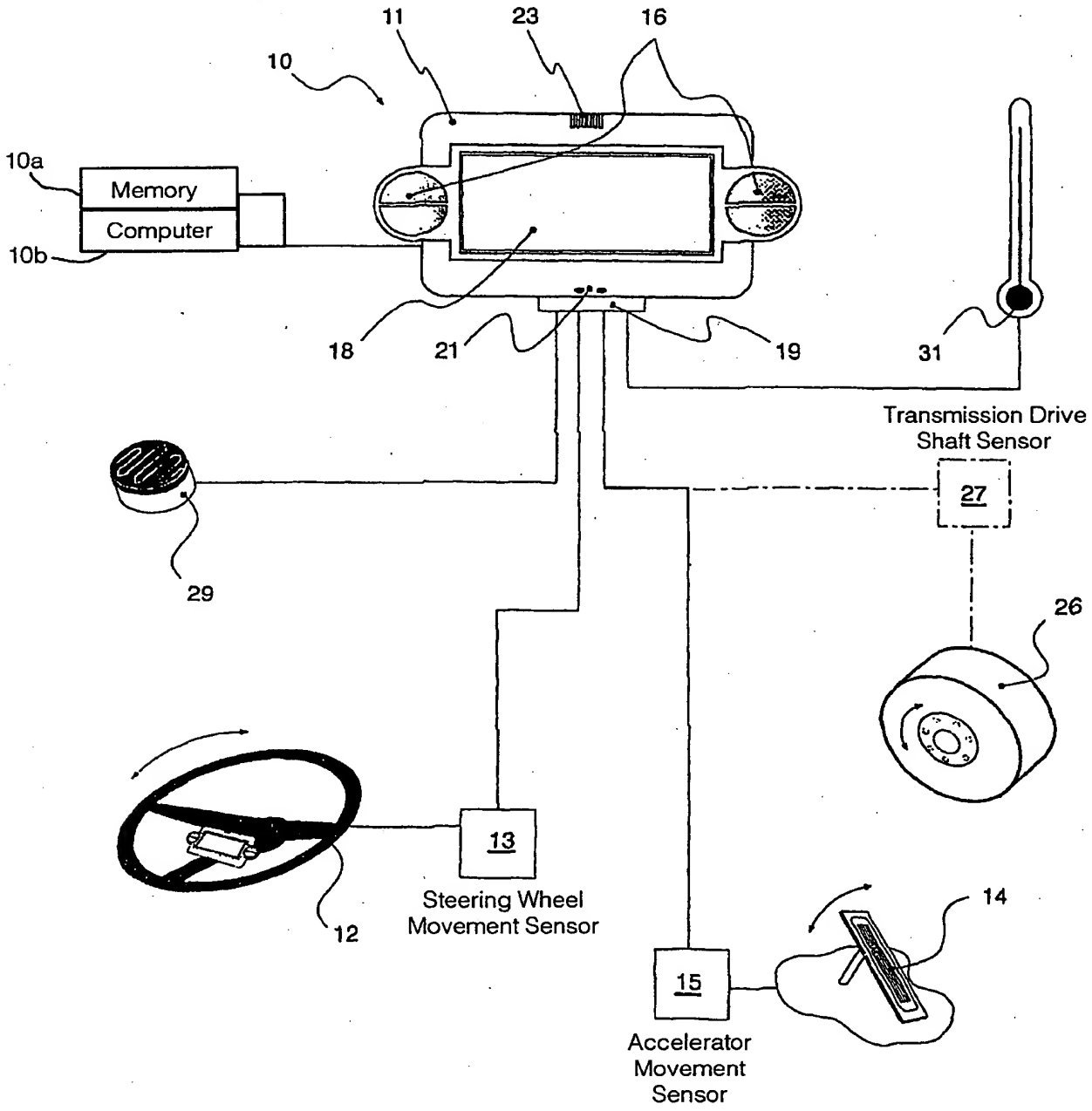

11
23
16
10
10a
Memory
Computer
10b
18
21
19
31
Transmission Drive
Shaft Sensor
27
29
26
13
Steering Wheel
Movement Sensor
12
14
15
Accelerator
Movement
Sensor

Figure 1

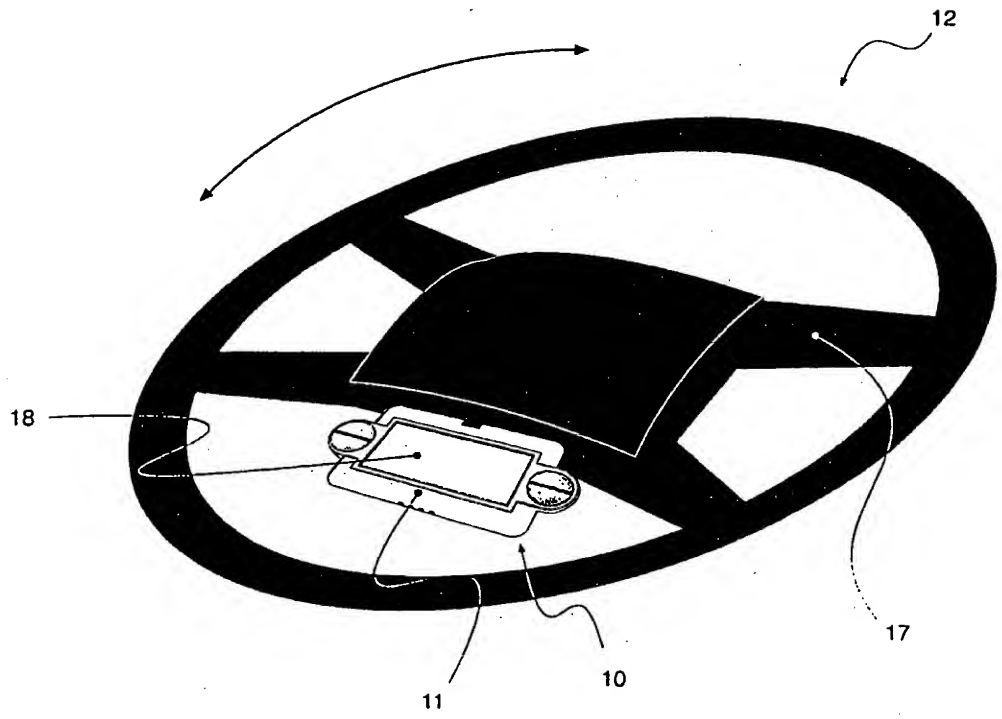


Figure 2

LIKELIHOOD OF FALLING ASLEEP 1= unlikely, 2= possibly, 3= likely, 4= very likely, 5= certain

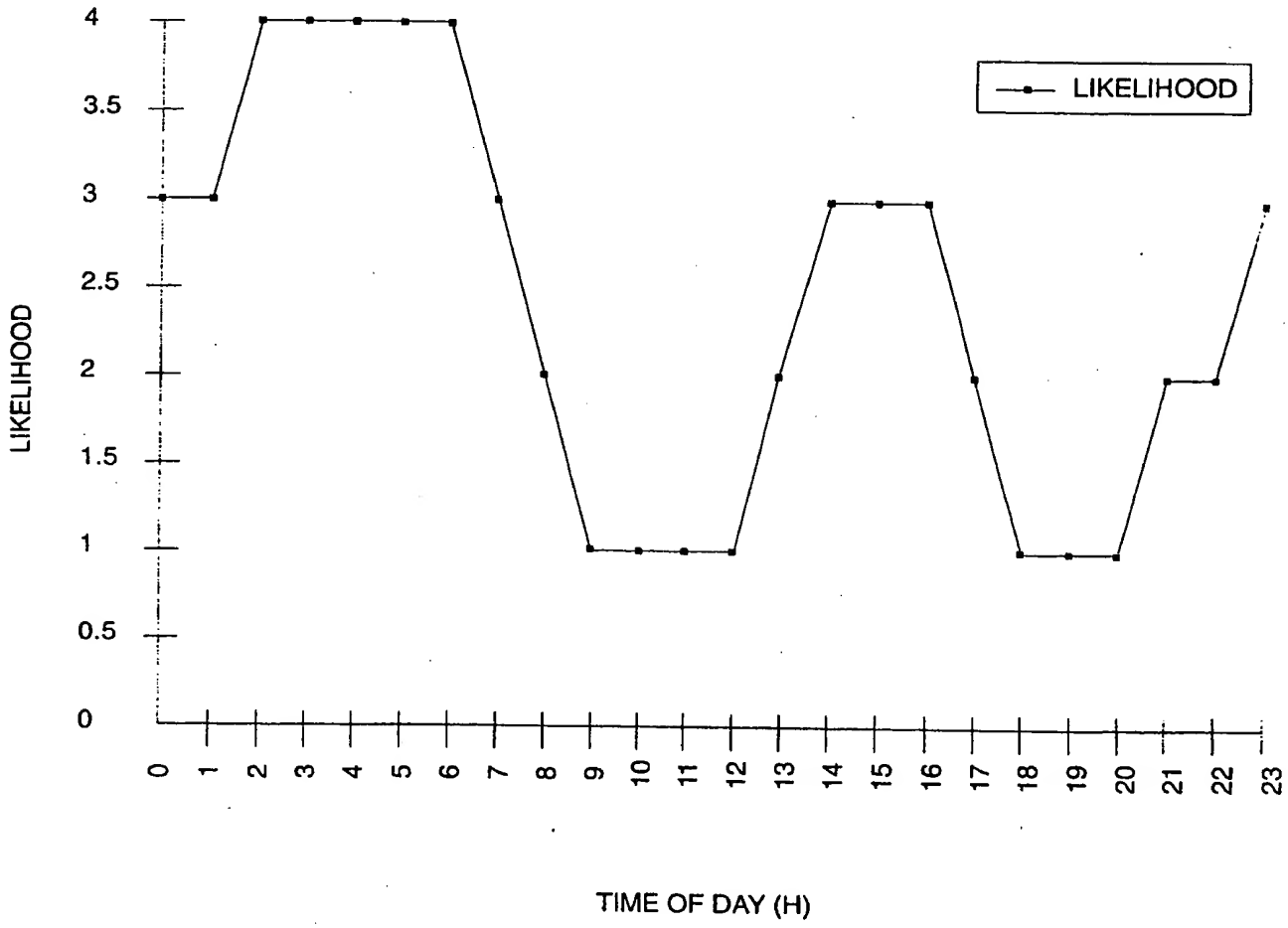


Figure 3

Figure 4

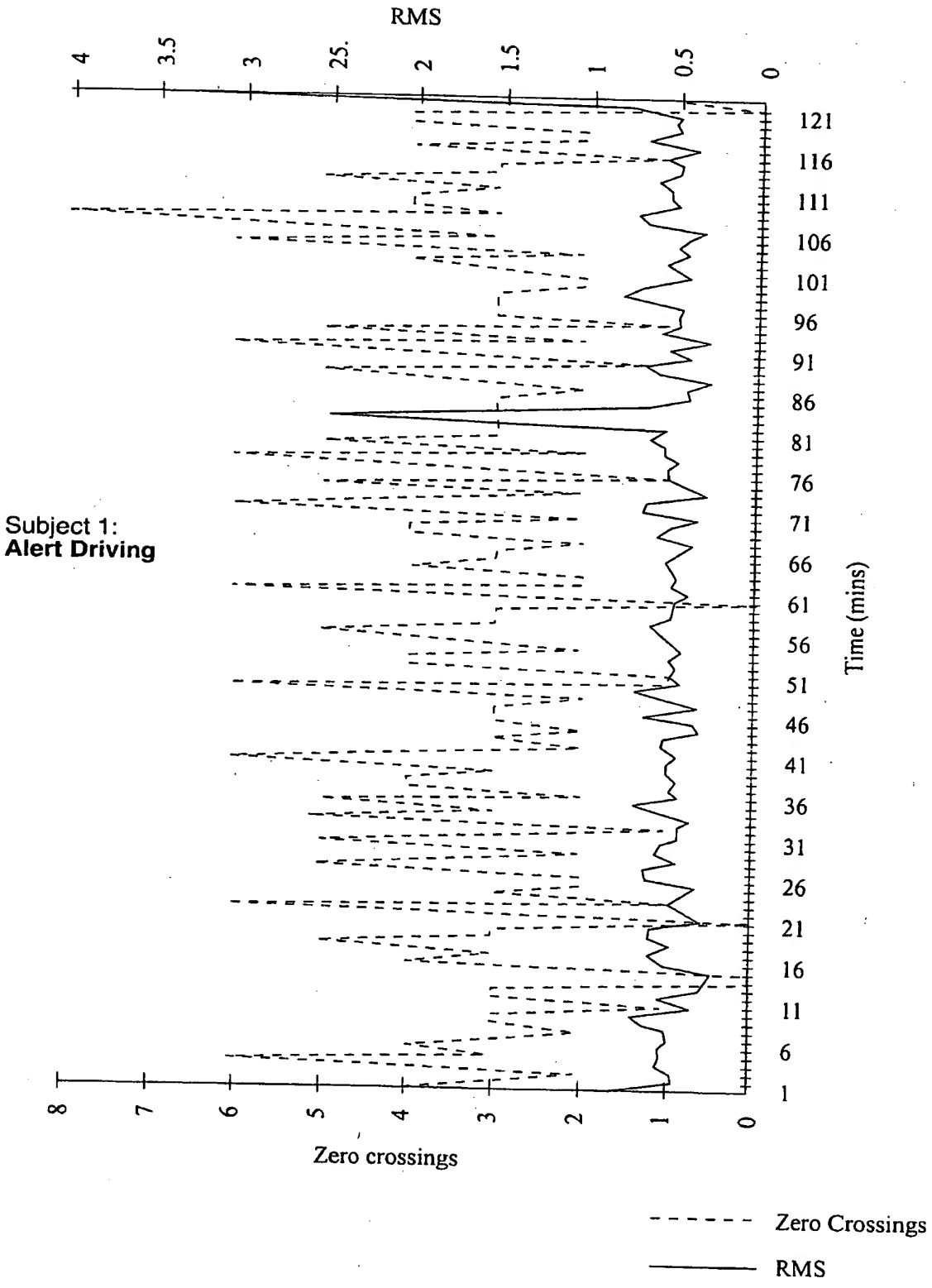

RMS
4
3.5
3
25.
2
1.5
1
0.5
0
121
116
111
106
101
96
91
86
81
76
71
66
61
56
51
46
41
36
31
26
21
16
11
6
1
Time (mins)
Subject 1:
Alert Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Zero Crossings
RMS

Figure 5

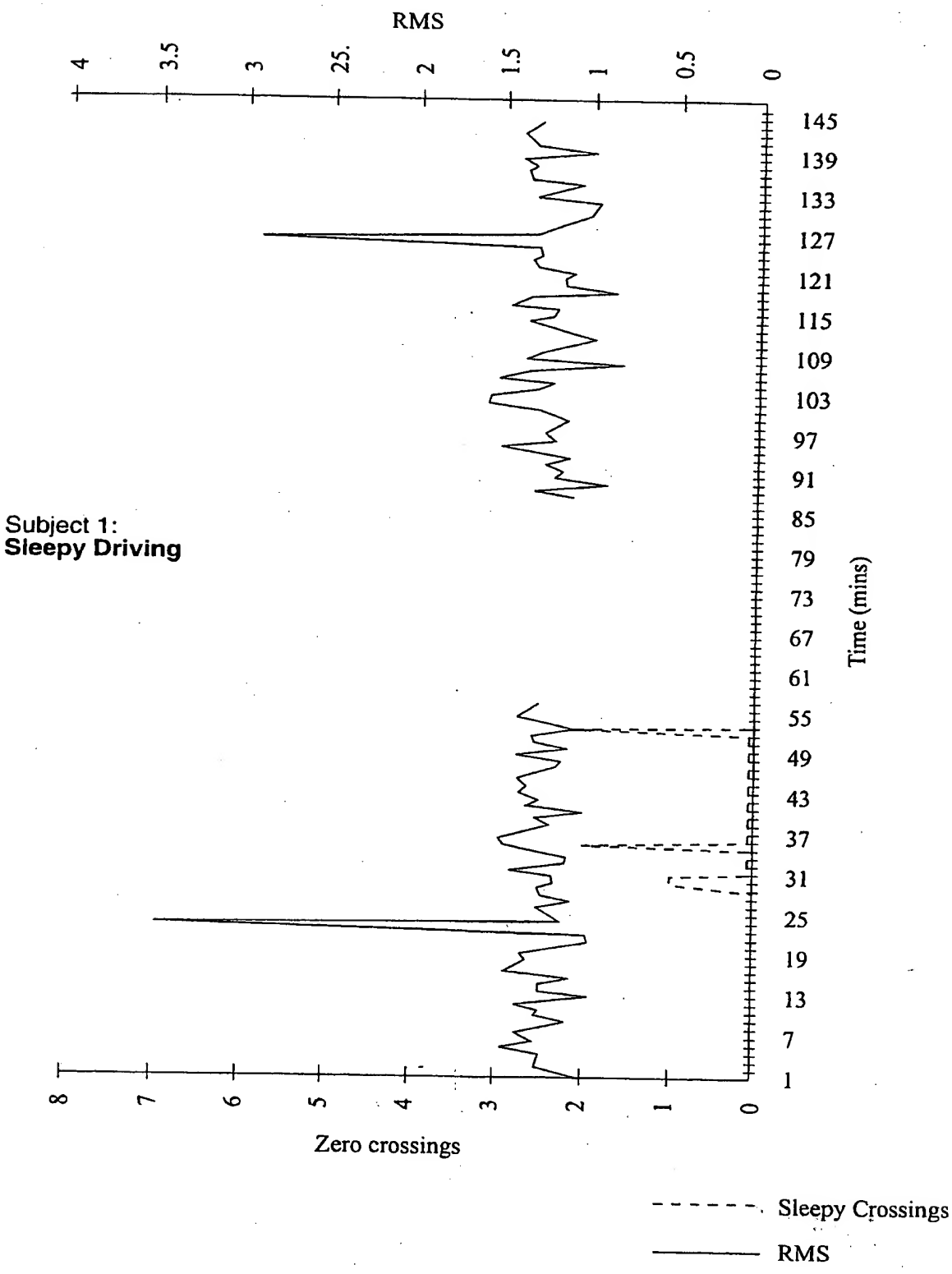

RMS
4
3.5
3
25.
2
1.5
1
0.5
0
145
139
133
127
121
115
109
103
97
91
85
79
73
67
61
55
49
43
37
31
25
19
13
7
1
Time (mins)
Subject 1:
Sleepy Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Sleepy Crossings
RMS

Figure 6

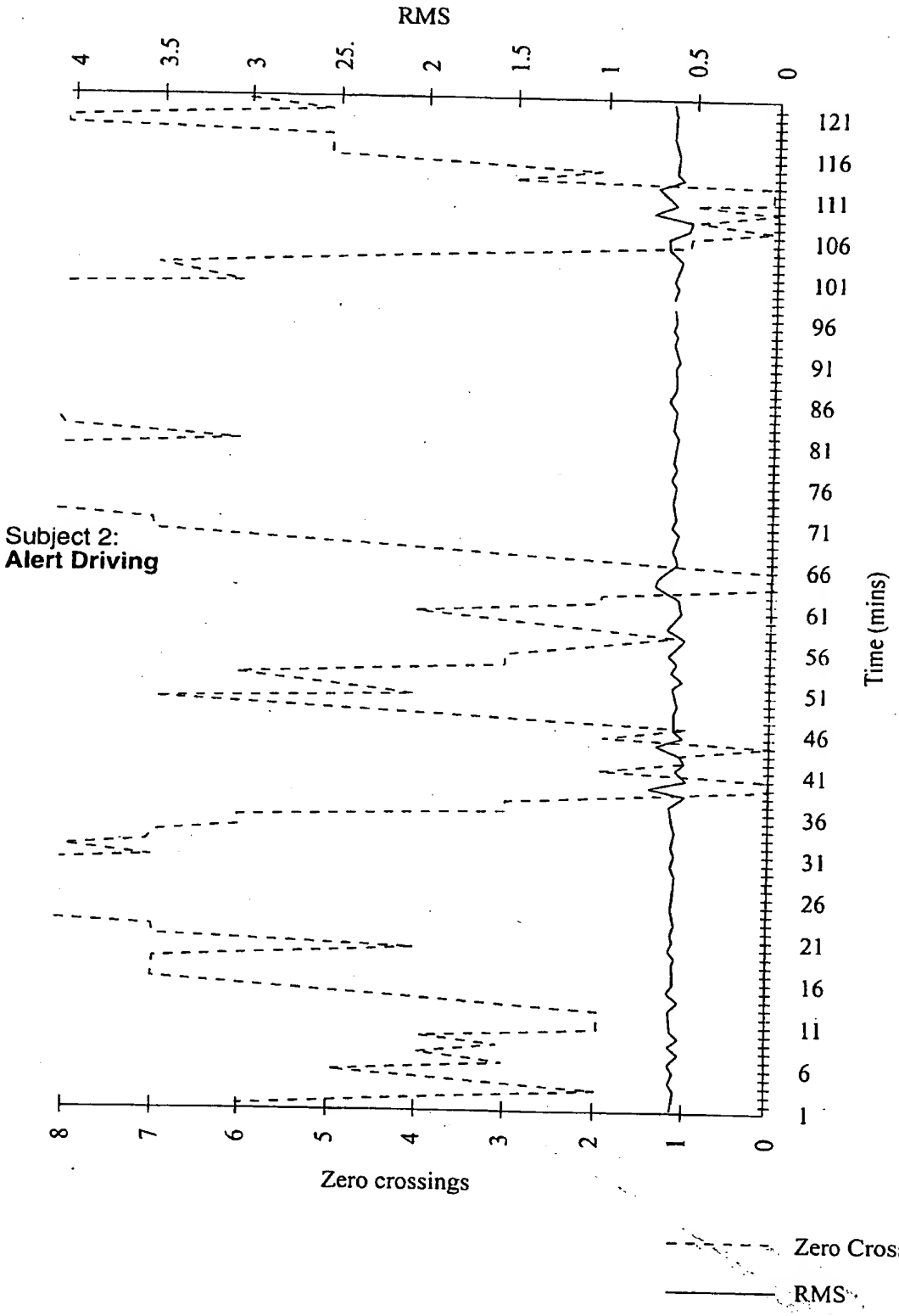

RMS
4
3.5
3
25.
2
1.5
1
0.5
0
121
116
111
106
101
96
91
86
81
76
71
66
61
56
51
46
41
36
31
26
21
16
11
6
1
Time (mins)
Subject 2:
Alert Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Zero Crossings
RMS

Figure 7

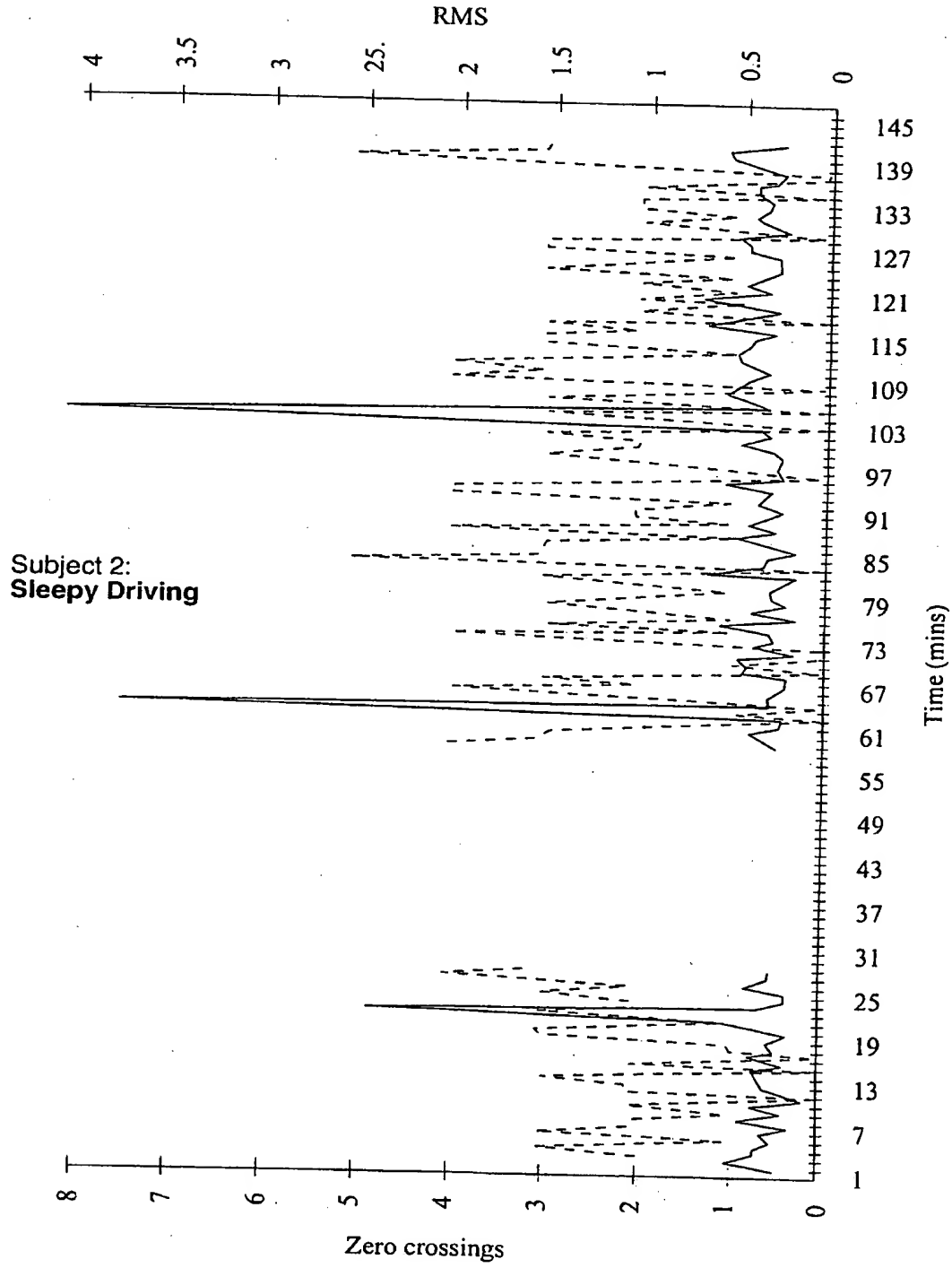

RMS
4
3.5
3
25.
2
1.5
1
0.5
0
145
139
133
127
121
115
109
103
97
91
85
79
73
67
61
55
49
43
37
31
25
19
13
7
1
Time (mins)
Subject 2:
Sleepy Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Sleepy Crossings
RMS

Figure 8

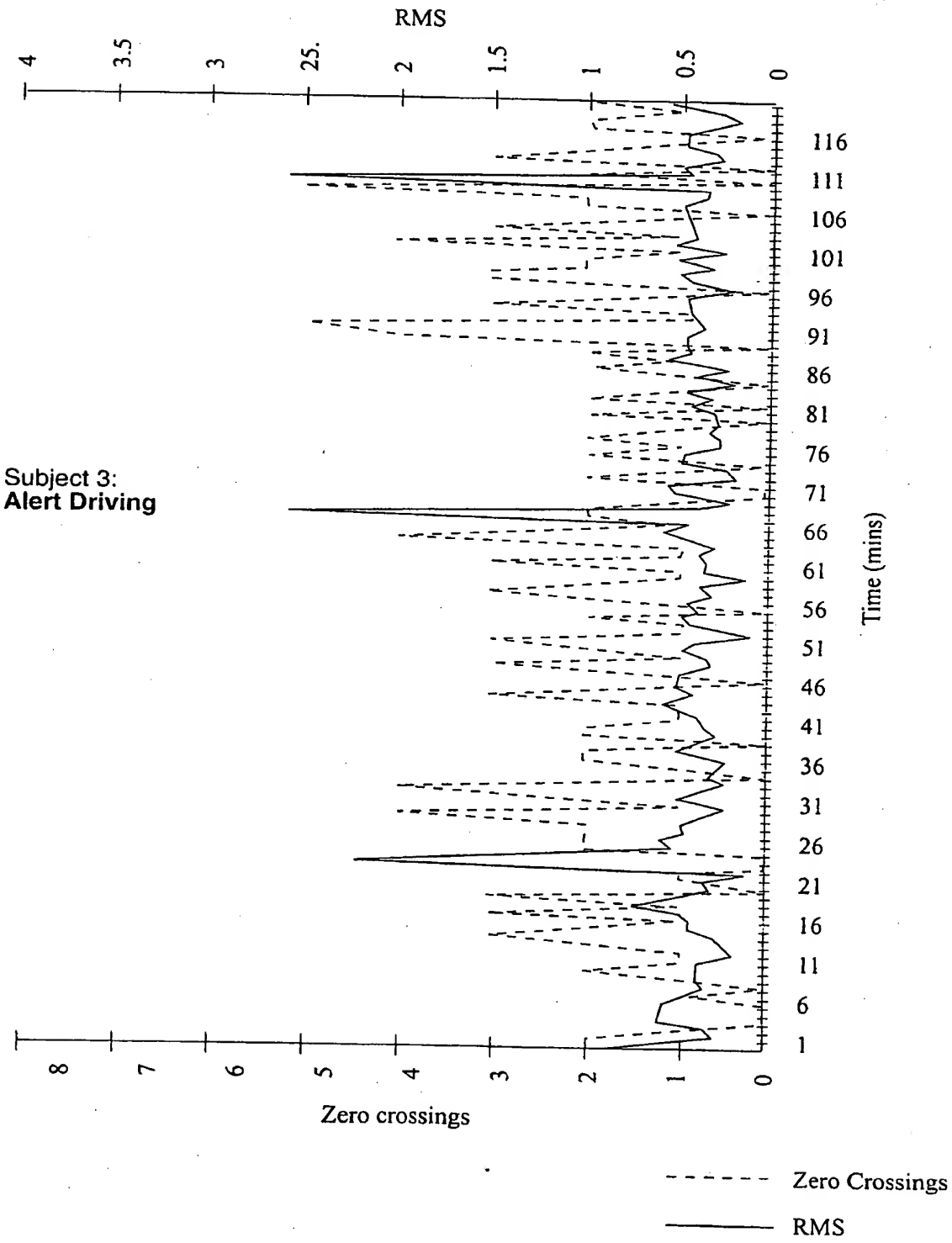
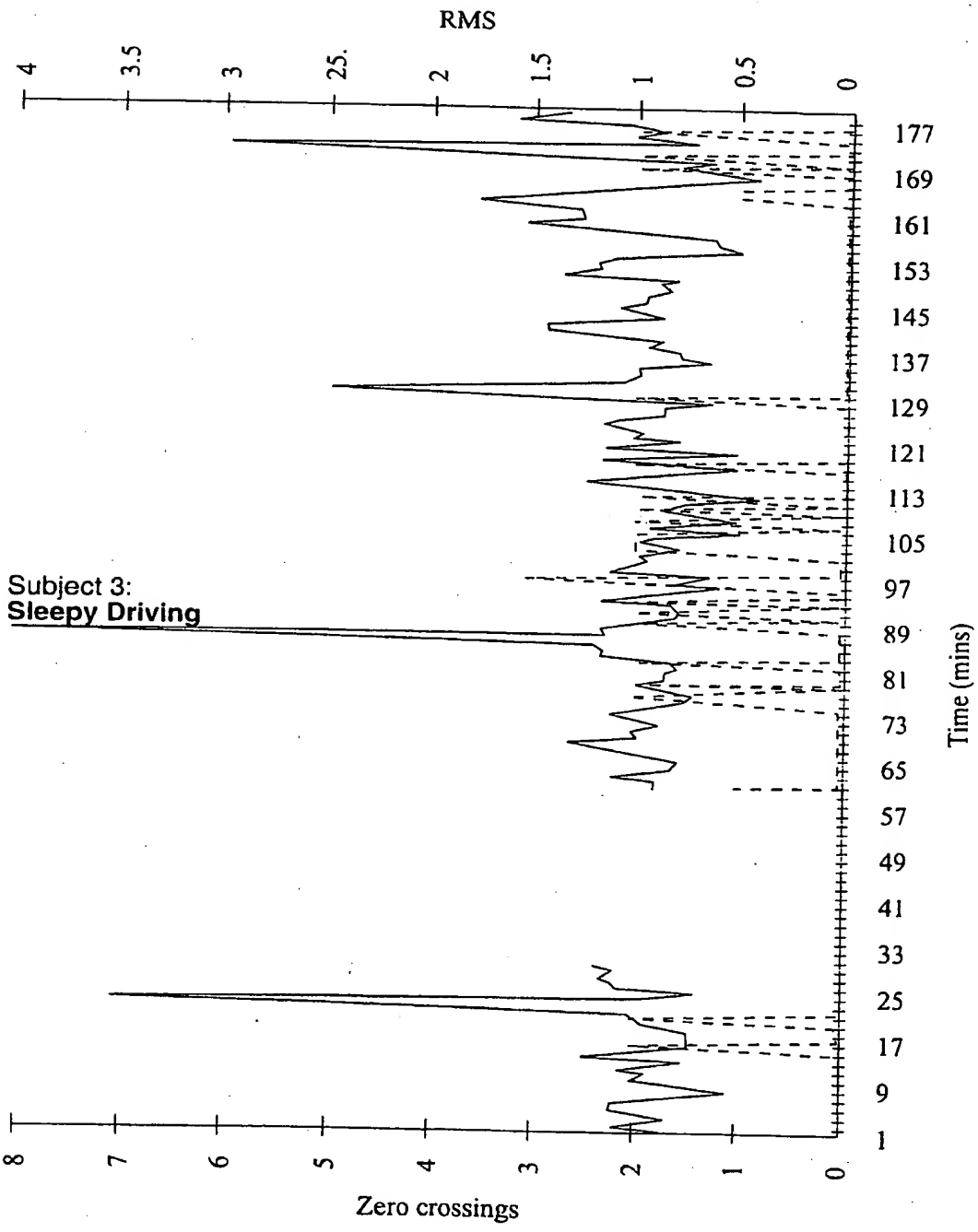

RMS
4
3.5
3
25.
2
1.5
1
0.5
0
116
111
106
101
96
91
86
81
76
71
66
61
56
51
46
41
36
31
26
21
16
11
6
1
Time (mins)
Subject 3:
Alert Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Zero Crossings
RMS

Figure 9


RMS
4
3.5
3
25.
2
1.5
1
0.5
0
177
169
161
153
145
137
129
121
113
105
97
89
81
73
65
57
49
41
33
25
17
9
1
Time (mins)
Subject 3:
Sleepy Driving
8
7
6
5
4
3
2
1
0
Zero crossings
Sleepy Crossings
RMS

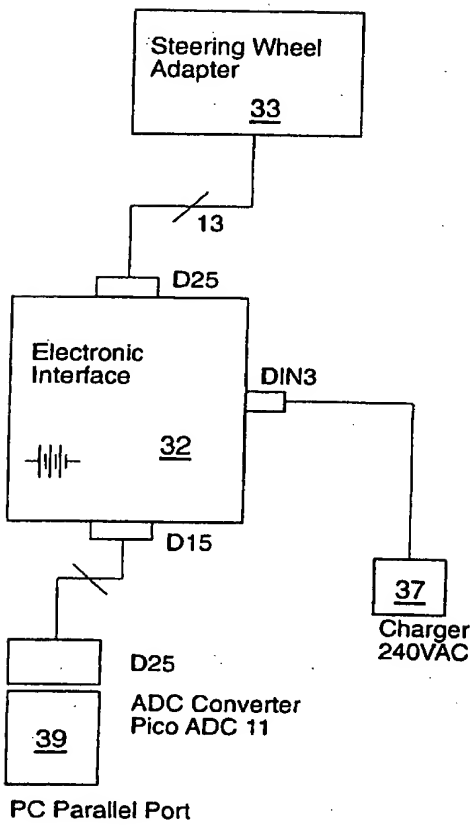


Figure 10

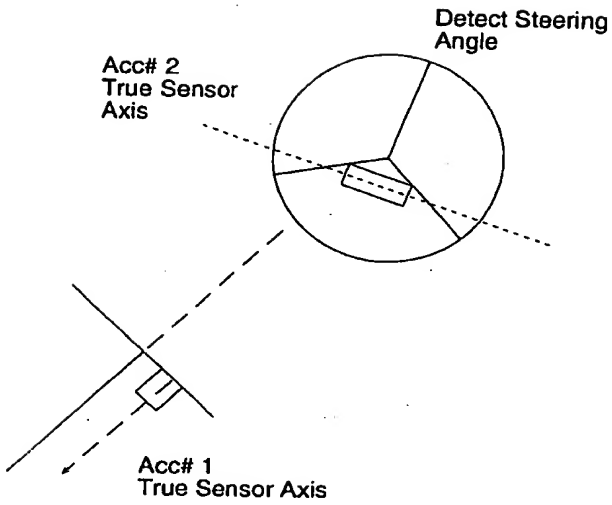


Figure 11

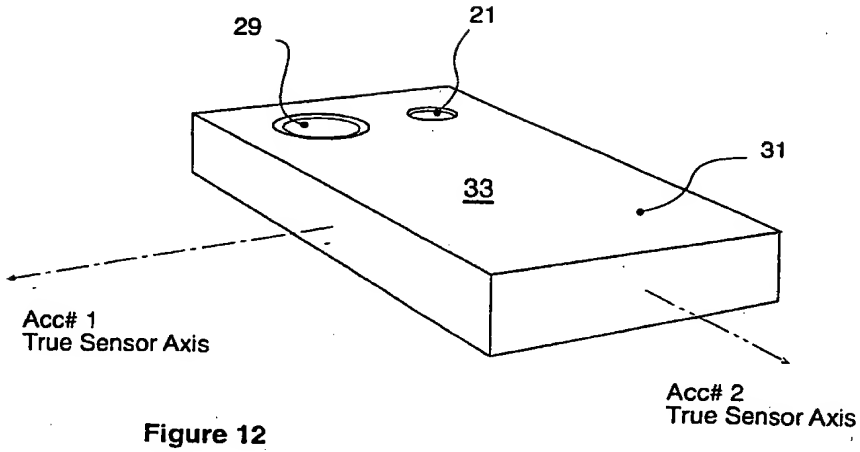
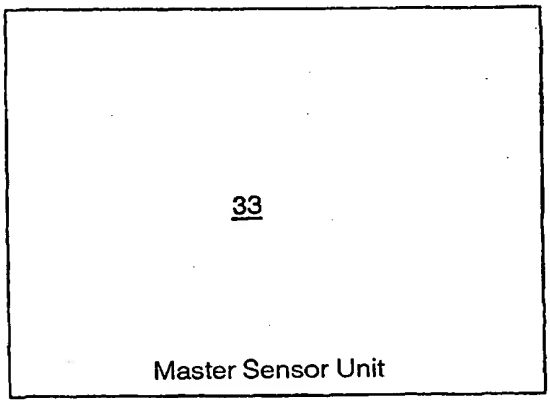


Figure 12

Rear panel

Figure 13D



Top View

Figure 13C

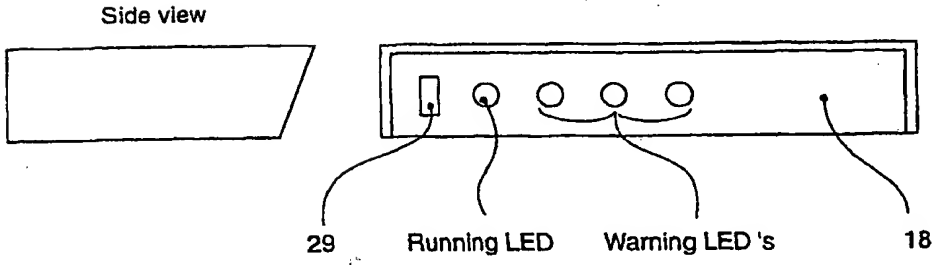


Figure 13B

Figure 13A

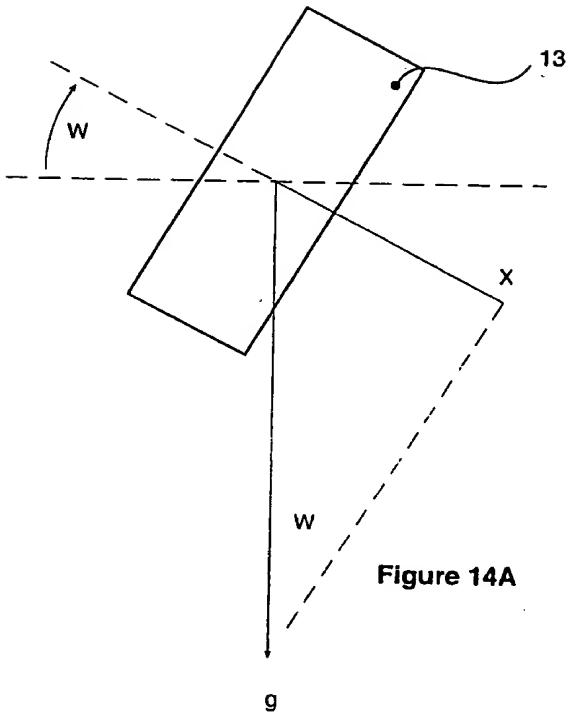


Figure 14A

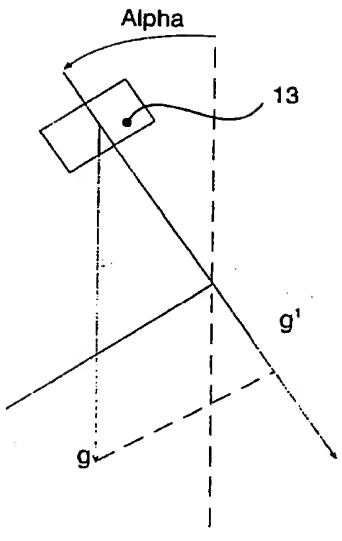


Figure 14B

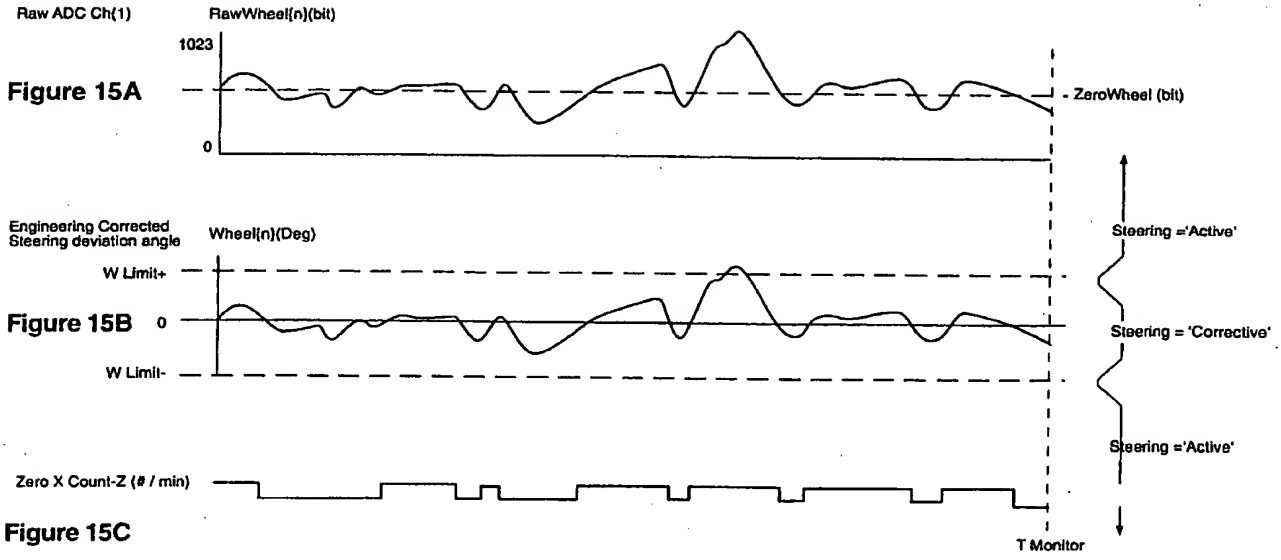


Figure 15A

Figure 15B

Figure 15C

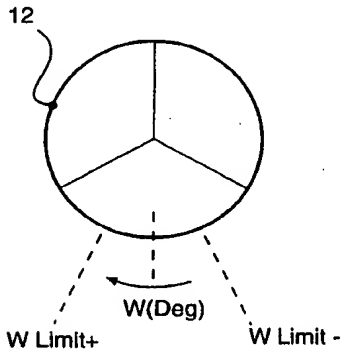


Figure 15D

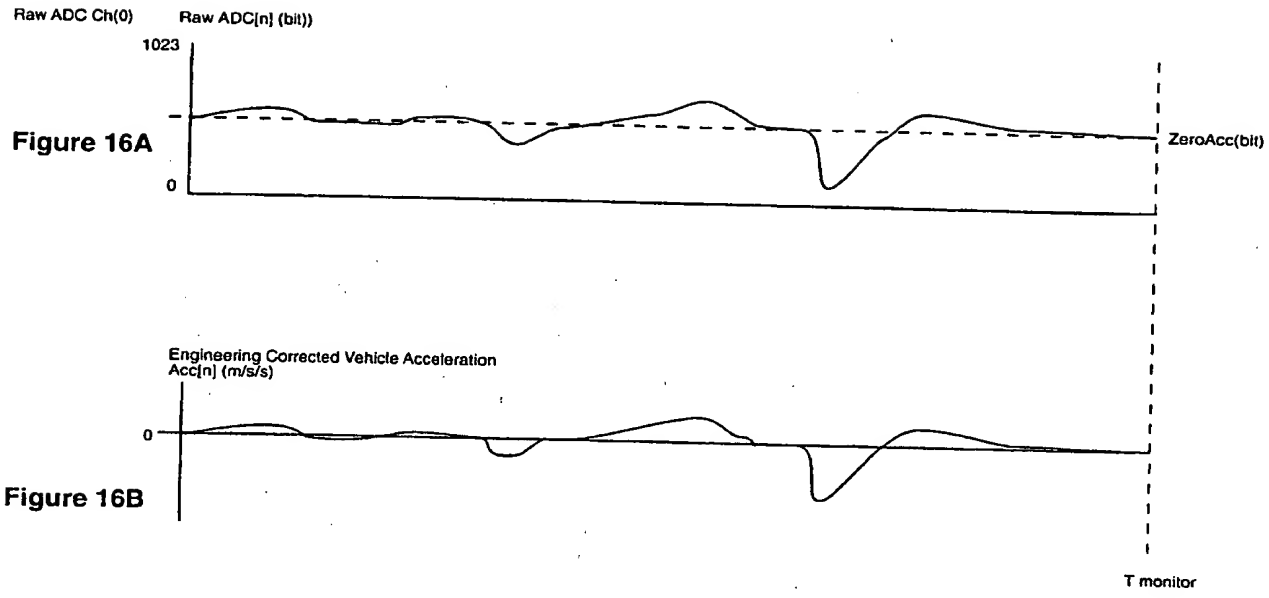


Figure 16A

Figure 16B

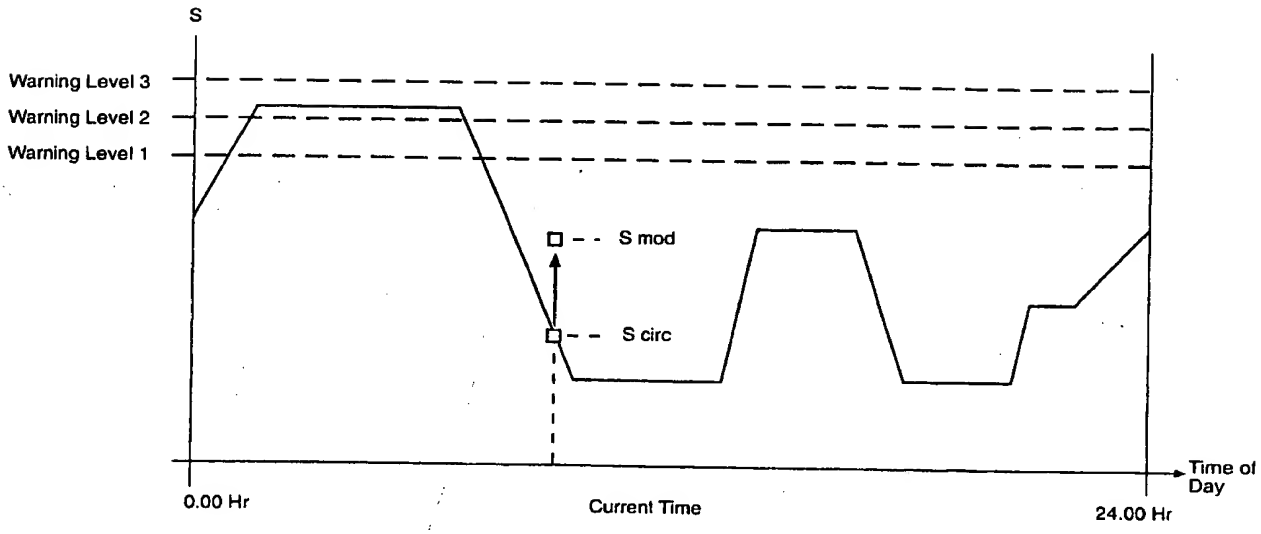

S
Warning Level 3
Warning Level 2
Warning Level 1
S mod
S circ
Time of Day
0.00 Hr
Current Time
24.00 Hr

Figure 17

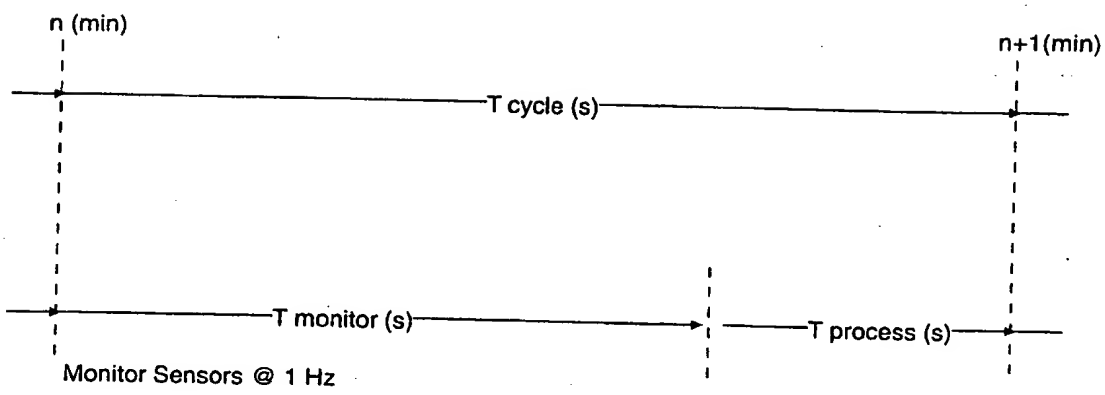
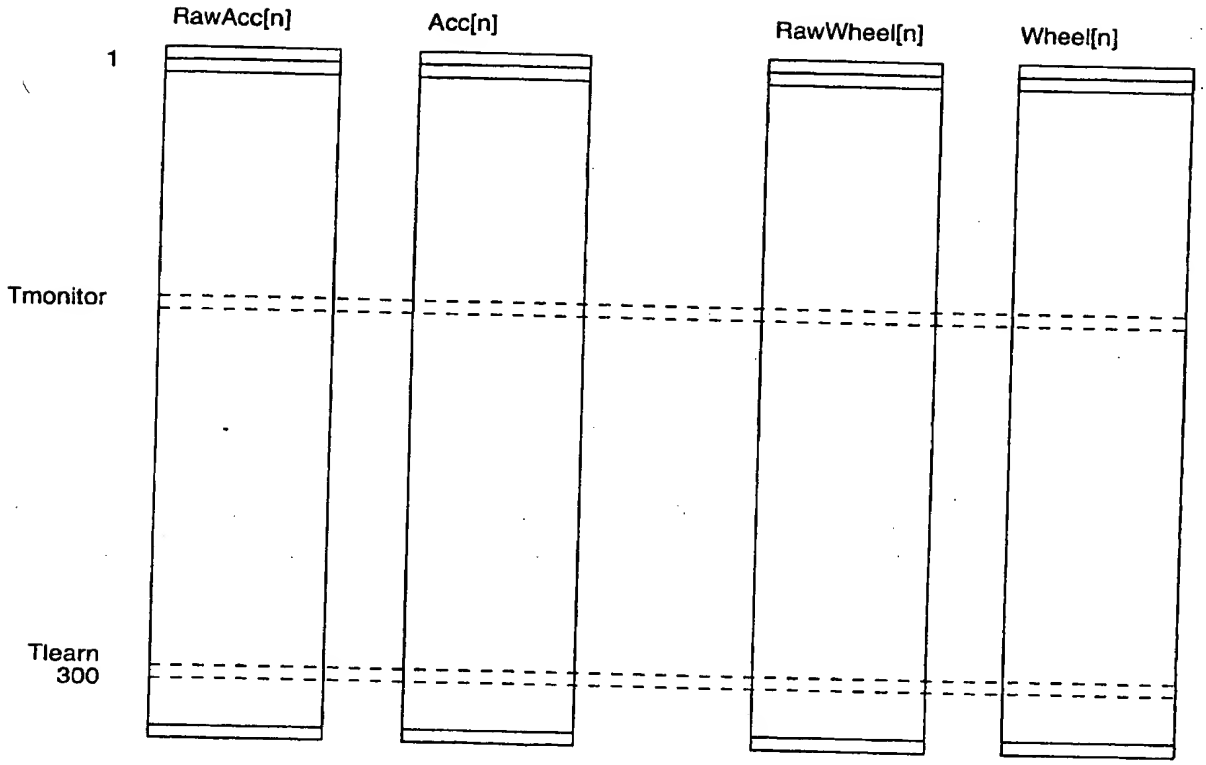

n (min)
n+1(min)
T cycle (s)
T monitor (s)
T process (s)
Monitor Sensors @ 1 Hz

Figure 18

Figure 19



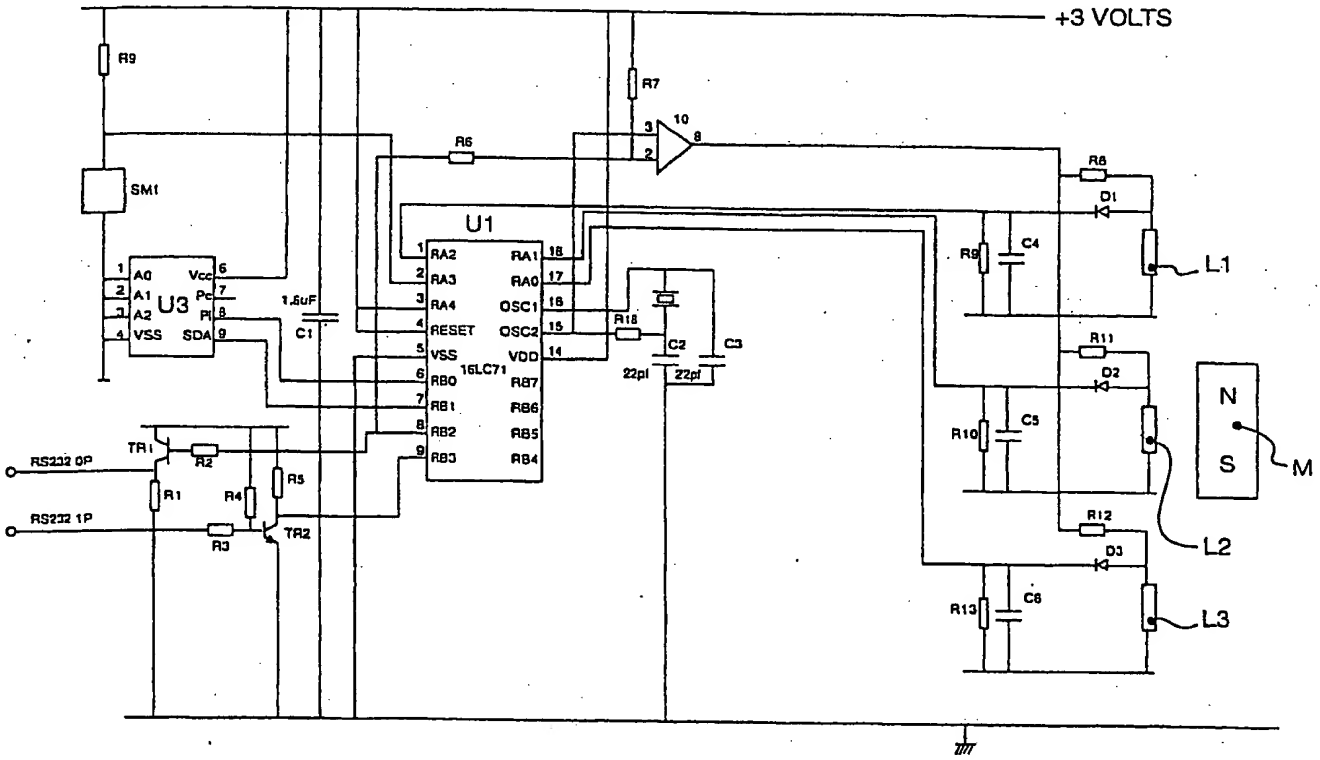


Figure 20

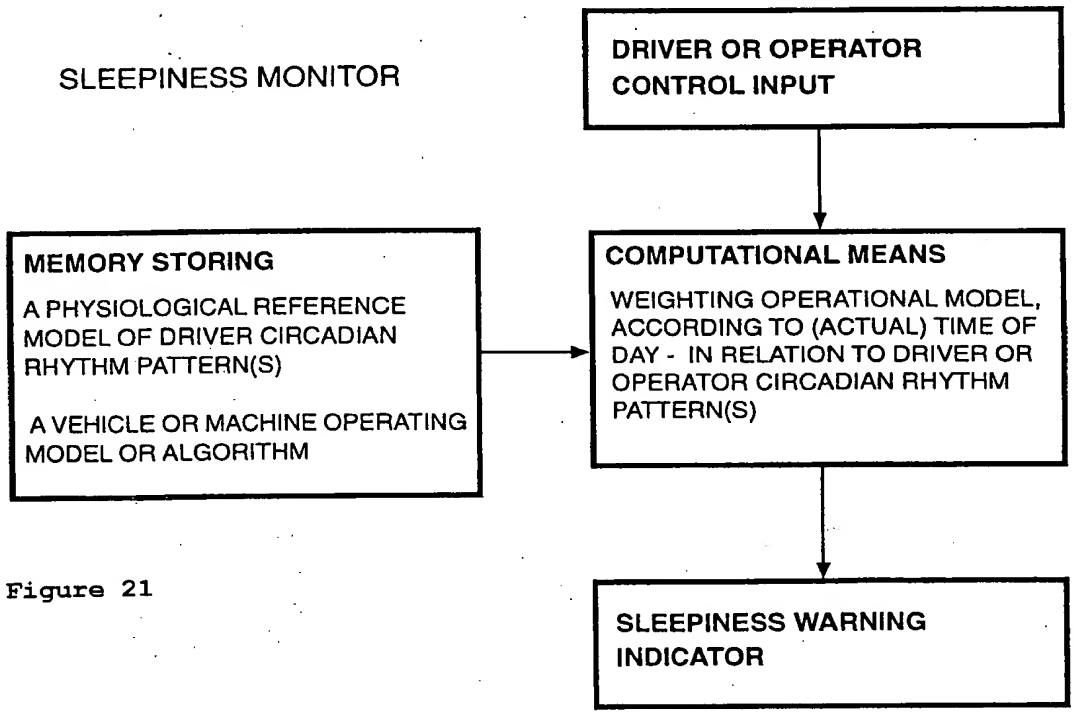


Figure 21

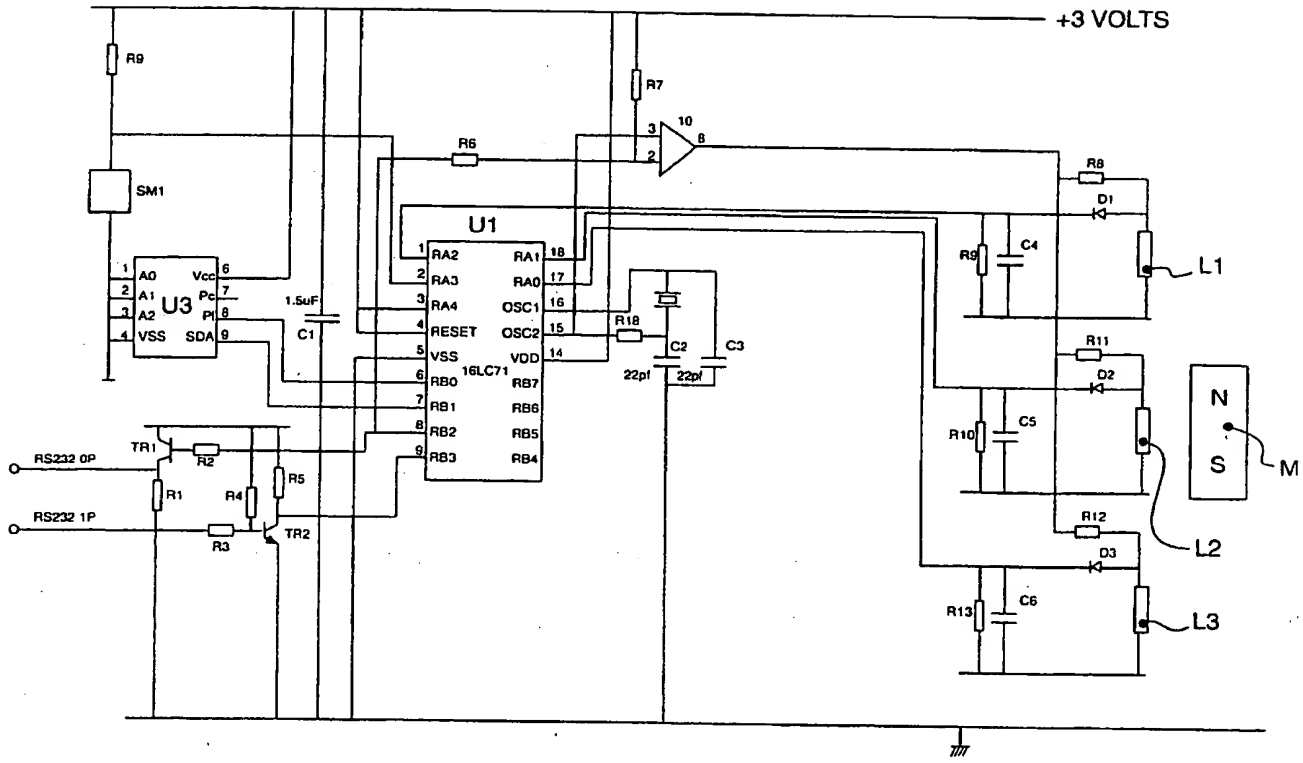

+3 VOLTS
R9
R7
R6
SM1
U1
U3
A0
A1
A2
VSS
Vcc
Pc
Pl
SDA
1.5uF
C1
RA2
RA3
RA4
RESET
VSS
RB0
RB1
RB2
RB3
16LC71
RA1
RA0
OSC1
OSC2
VDD
RB7
RB6
RB5
RB4
R18
C2
C3
22pf
22pf
R8
D1
R9
C4
L1
R11
D2
R10
C5
N
S
M
L2
R12
D3
R13
C6
L3
TR1
R2
RS232 0P
R1
R4
R5
RS232 1P
R3
TR2

Figure 20

Table 1

Acc # 1-Vehicle Motion
Acc # 2-Wheel Angle
Light Sensor - Ambient
Temp Sensor - Ambient
Sounder
Mark Button

Table 2

W - Wheel Rotation Angle
X - Measured component of g in sensor axis (m/s/s)
K wheel - Sensor scaling factor (mm/s/s/bit)
g - Gravity 9.81 m/s/s
g - Gravity Vector Component in wheel Plane

$\text{Sin } W = X / g$

$X = k \text{ wheel} / 1000 \times (Ch(1)-\text{ZeroWheel}) \times 1/\text{Cos}(\text{Alpha})$

$\text{Sin } W = k \text{ wheel} / (1000 \times g) \times (Ch(1)-\text{ZeroWheel}) \times (1/\text{Cos}(\text{Alpha}))$

$W + \text{ArcSin} [\text{Kwheel} /(1000 \times g) \times (Ch(1)-\text{ZeroWheel}) \times 1/\text{Cos}(\text{Alpha})]$

Table 3

RMS Steering Angle- $R(\text{Deg}) = \sqrt{\frac{\sum \text{Wheel}[n]^2}{n}}$

Table 4

Bound Check	
W Limit- < W < W Limit+	Steering Mode=Corrective
W < W Limit-	Steering Mode=Active
W > W Limit+	Steering Mode=Active

Table 5

$$\text{RMS Vehicle Acceleration-G(m/s/s)} = \sqrt{\frac{\sum \text{Acc[n]}^2}{n}}$$

Table 6

T cycle = 60s T monitor = 50s T process = 10s	Calculate Parameters Test & Issue Warnings Update Screen Display Store Sensor Data > Disk Store Calculated Parameters > Disk

Table 7

Note:

Data storage @ 1Hz
ZeroAcc=Average {RawAcc[n]}
ZeroWheel=Average {RawWheel[n]}
Ch(N)=Raw ADC Value (bit)

Table 8

Acc[n] = Kacc/1000 x (RawAcc[n]-ZeroAcc)x1/Cos(Alpha)

(m/s/s) (mm/s/s/bit) (bit) (bit)

Wheel[n] = ArcSin [Kwheel/(1000x9.81) x (RawWheel[n]-ZeroWheel)x1/Cos(Alpha)]

(Deg) (mm/s/s/bit) (bit) (bit)

I = Klight/1000 x (Ch(2)-ZeroLight)

(KLx) (Lx/bit) (bit) (bit)

T = Ktemp/1000 x (Ch(3) - ZeroTemp)

(DegC) (mDegC/bit) (bit) (bit)

Table 9

Engineering Scaling Factors	
K acc (mm/s/s/bit)	Acceleration Channel
K wheel (mm/s/s/bit)	Steering Channel
K light (Lx/bit)	Light Channel
K temp (mDegC/bit)	Temp Channel
ZeroLight (bit)	Intercept adjust - Light
ZeroTemp (bit)	Intercept adjust - Temp
Alpha (Deg)	Steering Wheel Inclination from Vertical
Hysterisis (Deg)	Hesterisis factor - Zero X analysis

Table 10

Sleep Propensity Algorithm - Definition	
S mod=S circ + S zerox + S rms + S light + S temp + S sleep + S road + S trip	
Elemental	Bound Limit
S mod	0<S mod <1
S circ	0<S circ <1
S zerox = (F zerox/100) (Z ref-Z)	0<S zerox
S rms = (F rms/100) (R-R ref)	0<S rms
S light = (F light/100) (I ref -I)	0<S light
S temp = (F temp/100) (T -T ref)	0<S temp
S sleep = (F sleep/100) (H ref - (HxQ))	0<S sleep
S road = (F road/100) (G ref -G)	0<S road
S trip = (F trip/100) x D	0<S trip

Table 11

Algorithm Elementals - S	
S mod (S)	Modified Sleep Propensity Factor-Range 0...1
S circ (S)	Current Circadian Sleep Propensity Value
S zerox (S)	Current Corrective Steering Reversal Rate Deficit
S rms (S)	Current RMS Corrective Steering Amplitude Surfit
S light (S)	Current Ambient Lighting Intensity Deficit
S temp (S)	Current Ambient Temperature Surfit
S sleep (S)	Prior Sleep Good Hours Deficit
S road (S)	Current Road Activity Deficit
S trip (S)	Accumulated Trip Duration

Table 12

Algorithm Weighting Factors - F	
Note : Factors are % S Unit per Parameter Unit	
F zerox (%S/#/min)	Corrective Steering Reversal Rate Deficit - % Factor
F rms (%S/Deg)	RMS Corrective Steering Amplitude Surfit - % Factor
F light (%S/kLx)	Average Ambient Lighting Intensity Deficit - % Factor
F temp (%S/DegC)	Average Ambient Temperature Surfit - % Factor
F sleep (%S/Hr)	Prior to Good Hours Sleep Deficit - % Factor
F road (%S/m/s/s)	Road Activity Deficit - % Factor
F trip (%S/Hr)	Accumulated Trip Duration - % Factor

Table 13

Algorithm Reference Offfsets - ref	
Z ref (#/min)	Corrective Steering Reversal Rate - Ref Offset Corresponds to 'Alert ' Driving Subject Dependent
R ref (Deg)	Corrective Steering RMS Amplitude - Ref Offset Corresponds to 'Alert ' Driving Subject Dependent
I ref (kLx)	Average Ambient Lighting Intensity - Ref Offset Corresponds to moderate daylight
T ref (DegC)	Average Ambient Temperature - Ref Offset Corresponds to moderate environment
H ref (Hr)	Prior to Good Hours Sleep - Ref Offset Corresponds to optimum value
G ref (m/s/s)	Road Activity - RMS Acceleration / Deceleration - Ref Offset

Table 14

Algorithm Dynamic Variables	
Z (#/min)	Current Corrective Steering Zero X Rate
R (Deg)	Current RMS Correvtive Steering Amplitude
I (kLx)	Current Ambient Lighting Intensity
T(DegC)	Current Ambient Temperature
G (m/s/s)	Current Road Activity - RMS Acceleration / Deceleration
D(Hr)	Accumulated Trip Duration
H(Hr)	Actual Hours of Prior Sleep
Q (#)	Prior Sleep Quality - Normalised Scale 0...1
Qx (#)	Prior Sleep Quality User Scale 1,2,3,4,5 Q=Qx/5

Table 15

Steering Mode & Steering Limit -W limit	
W limit (Deg)	Decision limit - Steering mode detection +W limit >W> -W limit >>> Corrective +W limit <W< -W limit >>> Active
Steering Mode	Steering mode decision ACTIVE, CORRECTIVE

Table 16

Alarm Levels & Alarm State	
Alarm Level 1 (s)	Alarm level threshold
Alarm Level 2 (s)	Alarm level threshold
Alarm Level 3 (s)	Alarm level threshold
Alarm Holdoff (min)	Initial alarm forced hold-off time - N minutes
Alarm State	Alarm status decision CLEAR, LEVEL1, LEVEL2, LEVEL3, HOLDOFF

Table 17

User Software Functions	
Set Display Parameters	
Enter New Values and <RET> or <RET> to bypass edit option.	
Display History (min)	Graphic display history length - Last N minutes
FSD (S)	Graphic display full scale - S unit (0.. 1)

Table 18

Data Directiory Structure
[ALGO] *.ALG Algorithm Data Files - Internal Format
[USER]*.ALG User Data Files - Internal Format
[XALGO]*.CSV Algorithm Data Files - CSV Format
[XUSER]*.CSV User Data Files - CSV Format
[XDRIVE]*.CSV Drive Mode Data Files - CSV Format
[XLEARN]*.CSV Learn Mode Data Files - CSV Format

Table 19

File Structure - Program Internal Format

Note : These files in program internal readable format

Configuration File - SLEEPALT.CFG

Save Set Values @ Program Shut Down
Load Set Value @ Program Initialisation

K acc	(mm/s/s/bit)
K wheel	(mm/s/s/bit)
K light	(Lx/bit)
K temp	(mDegC/bit)
K batt	(mV/bit)
ZeroLight	(bit)
ZeroTemp	(bit)
Hysterysis	(Deg)
Alpha	(Deg)
AlgorithmID	
UserID	
Circ[0] ... [23]	(S)
FSD	(0.. 1)
DisplayHist	(min)

Table 20

Algorithm Data File [ALGO]*.ALG	
F zerox	(%S/#/min)
F rms	(%S/Deg)
F light	(%S/Klx)
F temp	(%S/DegC)
F sleep	(%S/Hr)
F road	(%S/m/s/s)
F trip	(%s/Hr)
Z ref	(#/min)
R ref	(Deg)
I ref	(KLx)
T ref	(DegC)
H ref	(Hr)
G ref	(m/s/s)
Alarm1	(s)
Alarm2	(s)
Alarm3	(s)
AlarmHoldoff	(min)
W limit	(Deg)

Table 21

User Data File [USER]*.USR
UserName
UserDoB
UserSex

Table 22

Data File Structure - Drive Mode Data File [XDRIVE]*.CSV
Note: These files in external readable format - CSV

DriveID
File Ceation Date
Start Time (Hr 0.. 23)
Start Time (min 0.. 59)
UserID
AlgorithmID

Alarm1 (s)
Alarm2 (s)
Alarm3 (s)
AlarmHoldOff (min)

W limit (Deg)

H (Hr)
Q (0.. 1)

F zerox (%S/#/min)
F rms (%S/Deg)
F light (%S/kLx)
F temp (%S/DegC)
F sleep (%S/Hr)
F road (%S/m/s/s)
F trip (%S/Hr)

Z ref (#/min)
R ref (Deg)
I ref (Kix)
T ref (DegC)
H ref (Hr)
G ref (m/s/s)

Minute Count (min) ..... Repeat 1 .. N(min)
AlarmState
SteeringMode
Acceleration [1](m/s/s) Wheel[1](Deg)

Acceleration [50] Wheel[50]

Z (#/min)
R (Deg)
I (KLx)
T (DegC)
G (m/s/s)
D (Hr)

S mod (S)
S circ (S)
S zerox (S)
S rms (S)
S temp (S)
S sleep (S)
S road (S)
S trip (S)

DQC (Data Quality Code 0..255)

Table 23

Data File Structure - Learn Mode Data File [XLEARN]*.CSV

Note : These files in external readable format - CSV

Data File Structure - User Data File [XUSER]*.CSV

Note : These files in external readable format - CSV

UserID
File Creation Date

UserName
UserDoB
UserSex

Table 24

Data File Structure - Algorithm Data File [XALGO]*.CSV

Note : These files in external readable format - CSV

AlgorithmID

File Creation Date

F zerox (%S/#/min)

F rms (%S/Deg)

F light (%S/kLx)

F temp (%S/DegC)

F sleep (%S/Hr)

F road (%S/m/s/s)

F trip (%S/Hr)

Z ref (#/min)

R ref (Deg)

I ref (KLx)

T ref (DegC)

H ref (Hr)

G ref (m/s/s)

Alarm1 (s)

Alarm2 (s)

Alarm3 (s)

AlarmHoldOff (min)

W limit (Deg)